Standard Test Method for Core Shear Properties of Sandwich Constructions by Beam Flexure[1]

This standard is issued under the fixed designation C 393/C 393M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers determination of the core shear properties of flat sandwich constructions subjected to flexure in such a manner that the applied moments produce curvature of the sandwich facing planes. Permissible core material forms include those with continuous bonding surfaces (such as balsa wood and foams) as well as those with discontinuous bonding surfaces (such as honeycomb).

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. Within the text the inch-pound units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

C 273 Test Method for Shear Properties of Sandwich Core Materials
C 274 Terminology of Structural Sandwich Constructions
D 883 Terminology Relating to Plastics
D 3878 Terminology for Composite Materials
D 5229/D 5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
D 7249/D 7249M Test Method for Facing Properties of Sandwich Constructions by Long Beam Flexure
D 7250/D 7250M Practice for Determining Sandwich Beam Flexural and Shear Stiffness
E 4 Practices for Force Verification of Testing Machines
E 6 Terminology Relating to Methods of Mechanical Testing
E 122 Practice for Calculating Sample Size to Estimate, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process
E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E 456 Terminology Relating to Quality and Statistics
E 1309 Guide for Identification of Fiber-Reinforced Polymer-Matrix Composite Materials in Databases
E 1434 Guide for Recording Mechanical Test Data of Fiber-Reinforced Composite Materials in Databases

3. Terminology

3.1 *Definitions*—Terminology D 3878 defines terms relating to high-modulus fibers and their composites. Terminology C 274 defines terms relating to structural sandwich constructions. Terminology D 883 defines terms relating to plastics. Terminology E 6 defines terms relating to mechanical testing. Terminology E 456 and Practice E 177 define terms relating to statistics. In the event of a conflict between terms, Terminology D 3878 shall have precedence over the other terminologies.

3.2 *Symbols*:

b = specimen width
c = core thickness
CV = coefficient of variation statistic of a sample population for a given property (in percent)
d = sandwich total thickness
$D^{F,nom}$ = effective sandwich flexural stiffness
E_f = effective facing chord modulus
ϵ = measuring strain in facing
F^u = facing ultimate strength (tensile or compressive)
F_c = core compression allowable strength
F_s = core shear allowable strength
F_s^{ult} = core shear ultimate strength
F_s^{yield} = core shear yield strength
k = core shear strength factor to ensure core failure
L = length of loading span

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materials and is the direct responsibility of Subcommittee D30.09 on Sandwich Construction.

Current edition approved Sept. 1, 2006. Published October 2006. Originally approved in 1957. Last previous edition approved in 2000 as C 393 – 00.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

S = length of support span
l_{pad} = length of loading pad
n = number of specimens
P = applied force
P_{max} = maximum force carried by test specimen before failure
F_Z^{ftu} = ultimate flatwise tensile strength
P_{max} = maximum force carried by test specimen before failure
S_{n-1} = standard deviation statistic of a sample population for a given property
σ = facing stress or strength
t = facing thickness
x_1 = test result for an individual specimen from the sample population for a given property
x = mean or average (estimate of mean) of a sample population for a given property

4. Summary of Test Method

4.1 This test method consists of subjecting a beam of sandwich construction to a bending moment normal to the plane of the sandwich. Force versus deflection measurements are recorded.

4.2 The only acceptable failure modes are core shear or core-to-facing bond. Failure of the sandwich facing preceding failure of the core or core-to-facing bond is not an acceptable failure mode. Use Test Method D 7249 to determine facing strength.

5. Significance and Use

5.1 Flexure tests on flat sandwich construction may be conducted to determine the sandwich flexural stiffness, the core shear strength and shear modulus, or the facings compressive and tensile strengths. Tests to evaluate core shear strength may also be used to evaluate core-to-facing bonds.

5.2 This test method is limited to obtaining the core shear strength or core-to-facing shear strength and the stiffness of the sandwich beam, and to obtaining load-deflection data for use in calculating sandwich beam flexural and shear stiffness using Practice D 7250.

NOTE 1—Core shear strength and shear modulus are best determined in accordance with Test Method C 273 provided bare core material is available.

5.3 Facing strength is best determined in accordance with Test Method D 7249.

5.4 Practice D 7250 covers the determination of sandwich flexural and shear stiffness and core shear modulus using calculations involving measured deflections of sandwich flexure specimens.

5.5 This test method can be used to produce core shear strength and core-to-facing shear strength data for structural design allowables, material specifications, and research and development applications; it may also be used as a quality control test for bonded sandwich panels.

5.6 Factors that influence the shear strength and shall therefore be reported include the following: facing material, core material, adhesive material, methods of material fabrication, core geometry (cell size), core density, adhesive thickness, specimen geometry, specimen preparation, specimen conditioning, environment of testing, specimen alignment, loading procedure, speed of testing, and adhesive void content. Further, core-to-facing strength may be different between precured/bonded and co-cured facings in sandwich panels with the same core and facing material.

NOTE 2—Concentrated loads on beams with thin facings and low density cores can produce results that are difficult to interpret, especially close to the failure point. Wider load pads with rubber pads may assist in distributing the loads.

6. Interferences

6.1 *Material and Specimen Preparation*—Poor material fabrication practices and damage induced by improper specimen machining are known causes of high data scatter in composites and sandwich structures in general. A specific material factor that affects sandwich cores is variability in core density. Important aspects of sandwich core specimen preparation that contribute to data scatter include the existence of joints, voids or other core discontinuities, out-of-plane curvature, and surface roughness.

6.2 *Geometry*—Specific geometric factors that affect core shear strength include core orthotropy (that is, ribbon versus transverse direction for honeycomb core materials) and core cell geometry.

6.3 *Environment*—Results are affected by the environmental conditions under which specimens are conditioned, as well as the conditions under which the tests are conducted. Specimens tested in various environments can exhibit significant differences in both strength behavior and failure mode. Critical environments must be assessed independently for each specific combination of core material, facing material, and core-to-facing interfacial adhesive (if used) that is tested.

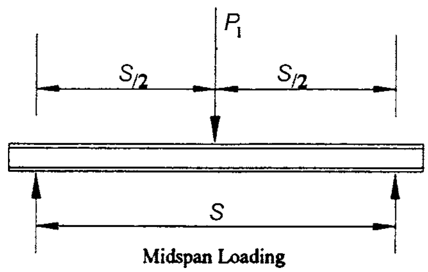
6.4 *Core Material*—If the core material has insufficient shear or compressive strength, it is possible that the core may locally crush at or near the loading points, thereby resulting in facing failure due to local stresses. In other cases, facing failure can cause local core crushing. When there is both facing and core failure in the vicinity of one of the loading points it can be difficult to determine the failure sequence in a post-mortem inspection of the specimen as the failed specimens look very similar for both sequences. For some core materials, the shear strength is a function of the direction that the core is oriented relative to the length of the specimen.

7. Apparatus

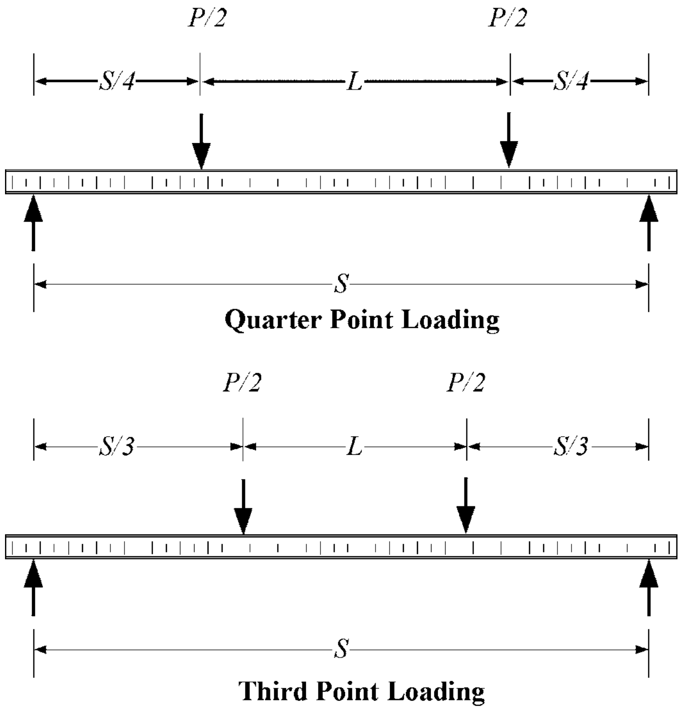
7.1 *Micrometers and Calipers*—A micrometer having a flat anvil interface, or a caliper of suitable size, shall be used. The instrument(s) shall have an accuracy of ±25 mm [±0.001 in.] for thickness measurement, and an accuracy of ±250 mm [±0.010 in.] for length and width measurement.

NOTE 3—The accuracies given above are based on achieving measurements that are within 1 % of the sample length, width and thickness.

7.2 *Loading Fixtures*—The loading fixture shall consist of either a 3-point or 4-point loading configuration with two support bars that span the specimen width located below the specimen, and one or two loading bars that span the specimen width located on the top of the specimen (Fig. 1), The force



(a) 3-Point Loading (Standard Configuration)



(b) 4-Point Loading (Non-Standard Configuration)

Configuration		Support Span (*S*)	Load Span (*L*)
Standard	3-Point (Mid-Span)	150 mm [6.0 in.]	0.0
Non-Standard	4-Point (Quarter-Span)	*S*	*S*/2
	4-Point (Third-Span)	*S*	*S*/3

FIG. 1 Loading Configurations

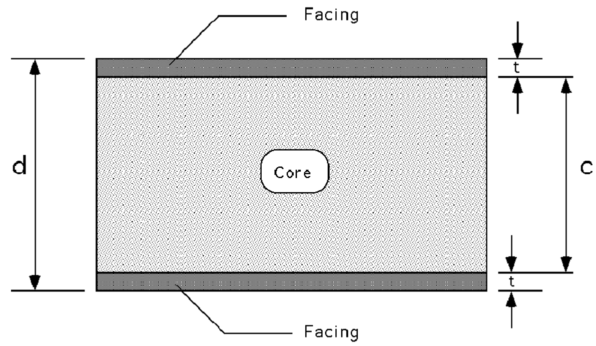


FIG. 2 Sandwich Panel Thickness Dimensions

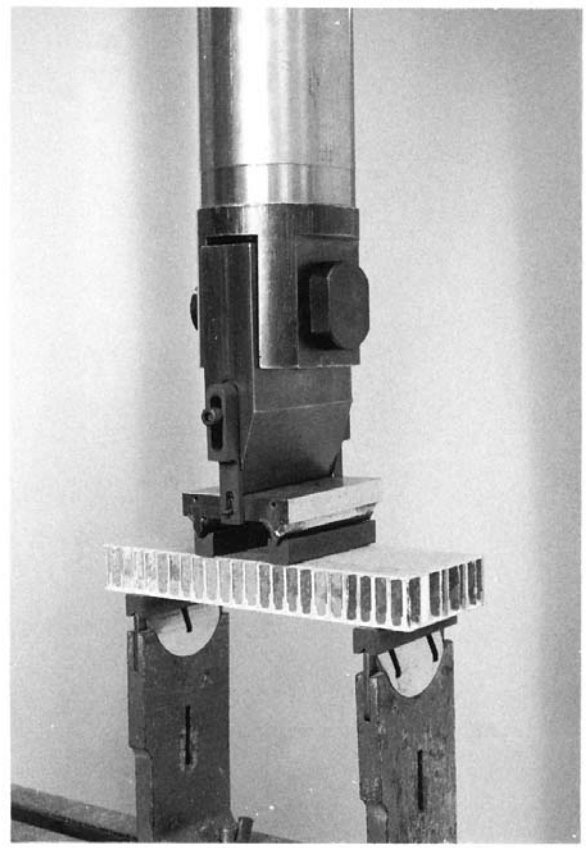


FIG. 3 Short Beam—4-Point (Third-Span) Short Beam Loading Configuration

shall be applied vertically through the loading bar(s), with the support bars fixed in place in the test machine.

7.2.1 *Standard Configuration*—The standard loading fixture shall be a 3-point configuration and shall have the centerlines of the support bars separated by a distance of 150 mm [6.0 in.].

7.2.2 *Non-Standard Configurations*—All other loading fixture configurations are considered non-standard, and details of the fixture geometry shall be documented in the test report. Fig. 3 shows a typical 4-point short beam test fixture. Non-standard 3- and 4-point loading configurations have been retained within this standard *(a)* for historical continuity with previous versions of Test Method C 393, *(b)* because some sandwich panel designs require the use of non-standard loading configurations to achieve core or bond failure modes, and *(c)* load-deflection data from non-standard configurations may be used with Practice D 7250 to obtain sandwich beam flexural and shear stiffnesses.

7.2.3 *Support and Loading Bars*—The bars shall be designed to allow free rotation of the specimen at the loading and support points. The bars shall have sufficient stiffness to avoid significant deflection of the bars under load; any obvious bowing of the bars or any gaps occurring between the bars and the test specimen during loading shall be considered significant deflection. The recommended configuration has a 25 mm [1.0 in.] wide flat steel loading block to contact the specimen (through rubber pressure pads) and is loaded via either a cylindrical pivot or a V-shaped bar riding in a V-groove in the top of the flat-bottomed steel loading pad. The tips of the V-shaped loading bars shall have a minimum radius of 3 mm [0.12 in.]. The V-groove in the loading pad shall have a radius larger than the loading bar tip and the angular opening of the groove shall be such that the sides of the loading bars do not contact the sides of the V-groove during the test. Loading bars consisting of 25 mm [1.0 in.] diameter steel cylinders may also be used, but there is a greater risk of local specimen crushing with cylindrical bars. Also, the load and support span lengths tend to increase as the specimen deflects when cylindrical loading bars without V-grooved loading pads are used (for example, rolling supports).

7.2.4 *Pressure Pads*—Rubber pressure pads having a Shore A durometer of approximately 60, a nominal width of 25 mm [1.0 in.], a nominal thickness of 3 mm [0.125 in.] and spanning the full width of the specimen shall be used between the loading bars and specimen to prevent local damage to the facings.

7.3 *Testing Machine*—The testing machine shall be in accordance with Practices E 4 and shall satisfy the following requirements:

7.3.1 *Testing Machine Configuration*—The testing machine shall have both an essentially stationary head and a movable head.

7.3.2 *Drive Mechanism*—The testing machine drive mechanism shall be capable of imparting to the movable head a controlled velocity with respect to the stationary head. The velocity of the movable head shall be capable of being regulated in accordance with 11.4.

7.3.3 *Force Indicator*—The testing machine force-sensing device shall be capable of indicating the total force being carried by the test specimen. This device shall be essentially free from inertia lag at the specified rate of testing and shall indicate the force with an accuracy over the force range(s) of interest of within ±1 % of the indicated value.

7.4 *Deflectometer (LVDT)*—The deflection of the specimen shall be measured in the center of the support span by a properly calibrated device having an accuracy of ±1 % or better.

NOTE 4—The use of crosshead or actuator displacement for the beam mid-span deflection produces inaccurate results, particularly for 4-point loading configurations; the direct measurement of the deflection of the mid-span of the beam must be made by a suitable instrument.

7.5 *Conditioning Chamber*—When conditioning materials at non-laboratory environments, a temperature/vapor-level controlled environmental conditioning chamber is required that shall be capable of maintaining the required temperature to within ±3°C [±5°F] and the required relative humidity level to within ±3 %. Chamber conditions shall be monitored either on an automated continuous basis or on a manual basis at regular intervals.

7.6 *Environmental Test Chamber*—An environmental test chamber is required for test environments other than ambient testing laboratory conditions. This chamber shall be capable of maintaining the gage section of the test specimen at the required test environment during the mechanical test.

8. Sampling and Test Specimen

8.1 *Sampling*—Test at least five specimens per test condition unless valid results can be gained through the use of fewer specimens, as in the case of a designed experiment. For statistically significant data, consult the procedures outlined in Practice E 122. Report the method of sampling.

8.2 *Geometry*—The standard specimen configuration should be used whenever the specimen design equations in 8.2.3 indicate that the specimen will produce the desired core or core-to-facing bond failure mode. In cases where the standard specimen configuration will not produce a desired failure, a non-standard specimen shall be designed to produce a core or bond failure mode.

8.2.1 *Standard Configuration*—The test specimen shall be rectangular in cross section, with a width of 75 mm [3.0 in.] and a length of 200 mm [8.0 in.]. The depth of the specimen shall be equal to the thickness of the sandwich construction.

8.2.2 *Non-Standard Configurations*—For non-standard specimen geometries the width shall be not less than twice the total thickness nor more than six times the total thickness, not less than three times the dimension of a core cell, nor greater than one half the span length. The specimen length shall be equal to the support span length plus 50 mm [2 in.] or plus one half the sandwich thickness, whichever is the greater. Limitations on the maximum specimen width are intended to allow for the use of simplified sandwich beam calculations; plate flexure effects must be considered for specimens that are wider than the restrictions specified above.

8.2.3 *Specimen Design*—Proper design of the sandwich flexure test specimen for determining shear strength of the core or core-to-facing bond is required to avoid facing failures. The facings must be sufficiently thick and/or the support span sufficiently short such that transverse shear forces are produced at applied forces low enough so that the allowable facing stress will not be exceeded. However, if the facings are too thick, the transverse shear force will be carried to a considerable extent by the facings, thus leading to a high apparent core shear strength as computed by the equations given in this standard. The following equations can be used to size the test specimen (these equations assume that both facings have the same thickness and modulus, and that the facing thickness is small relative to the core thickness [$t/c \leq \sim 0.10$]):

The support span length shall satisfy:

$$S \leq \frac{2k\sigma t}{F_s} + L \tag{1}$$

or, the core shear strength shall satisfy:

$$F_s \leq \frac{2k\sigma t}{(S - L)} \tag{2}$$

The core compression strength shall satisfy:

$$F_c \geq \frac{2(c + t)\sigma t}{(S - L)l_{pad}} \tag{3}$$

where:

S = support span length, mm [in.],
L = loading span length, mm [in.] (L = 0 for 3-point loading),
σ = expected facing ultimate strength, MPa [psi],
t = facing thickness, mm [in.],
c = core thickness,
F_s = estimated core shear strength, MPa [psi],

k = facing strength factor to ensure core failure (recommend k = 1.3),
l_{pad} = dimension of loading pad in specimen lengthwise direction, mm [in.], and
F_c = core compression allowable strength, MPa [psi].

8.3 *Facings*:

8.3.1 *Layup*—The apparent flexural stiffness obtained from this method may be dependent upon the facing stacking sequence, albeit to a much lesser degree than is typical for laminate flexure. For the standard test configuration, facings consisting of a laminated composite material shall be balanced and symmetric about the sandwich beam mid-plane.

8.3.2 *Stiffness*—For the standard specimen, the facings shall be the same material, thickness and layup. The calculations assume constant and equal upper and lower facing stiffness properties. This assumption may not be applicable for certain facing materials (such as aramid fiber composites) which have significantly different tensile and compressive moduli or which exhibit significant non-linear stress-strain behavior.

8.3.3 *Facing Thickness*—Accurate measurement of facing thickness is difficult after bonding or co-curing of the facings and core. The test requestor is responsible for specifying the facing thicknesses to be used for the calculations in this test method. For metallic or precured composite facings which are secondarily bonded to the core, the facing thickness should be measured prior to bonding. In these cases the test requestor may specify that either or both measured and nominal thicknesses be used in the calculations. For co-cured composite facings, the thicknesses are generally calculated using nominal per ply thickness values.

8.4 *Specimen Preparation and Machining*—Specimen preparation is important for this test method. Take precautions when cutting specimens from large panels to avoid notches, undercuts, rough or uneven surfaces, or delaminations due to inappropriate machining methods. Obtain final dimensions by water-lubricated precision sawing, milling, or grinding. The use of diamond coated machining tools has been found to be extremely effective for many material systems. Edges should be flat and parallel within the specified tolerances. Record and report the specimen cutting preparation method.

8.5 *Labeling*—Label the test specimens so that they will be distinct from each other and traceable back to the panel of origin, and will neither influence the test nor be affected by it.

9. Calibration

9.1 The accuracy of all measuring equipment shall have certified calibrations that are current at the time of use of the equipment.

10. Conditioning

10.1 The recommended pre-test specimen condition is effective moisture equilibrium at a specific relative humidity per Test Method D 5229/D 5229M; however, if the test requestor does not explicitly specify a pre-test conditioning environment, conditioning is not required and the test specimens may be tested as prepared.

10.2 The pre-test specimen conditioning process, to include specified environmental exposure levels and resulting moisture content, shall be reported with the test data.

NOTE 5—The term moisture, as used in Test Method D 5229/D 5229M, includes not only the vapor of a liquid and its condensate, but the liquid itself in large quantities, as for immersion.

10.3 If no explicit conditioning process is performed the specimen conditioning process shall be reported as “unconditioned” and the moisture content as “unknown”.

11. Procedure

11.1 *Parameters to Be Specified Before Test*:

11.1.1 The specimen sampling method, specimen geometry, and conditioning travelers (if required).

11.1.2 The properties and data reporting format desired.

11.1.3 The environmental conditioning test parameters.

11.1.4 The nominal thicknesses of the facing materials.

NOTE 6—Determine specific material property, accuracy, and data reporting requirements prior to test for proper selection of instrumentation and data recording equipment. Estimate the specimen strength to aid in transducer selection, calibration of equipment, and determination of equipment settings.

11.2 *General Instructions*:

11.2.1 Report any deviations from this test method, whether intentional or inadvertent.

11.2.2 Condition the specimens as required. Store the specimens in the conditioned environment until test time, if the test environment is different than the conditioning environment.

11.2.3 Before testing, measure and record the specimen length, width and thickness at three places in the test section. Measure the specimen length and width with an accuracy of ±250 mm [±0.010 in.]. Measure the specimen thickness with an accuracy of ±25 mm [±0.001 in.]. Record the dimensions to three significant figures in units of millimeters [inches].

11.3 Measure and record the length of the support and loading spans.

11.4 *Speed of Testing*—Set the speed of testing so as to produce failure within 3 to 6 min. If the ultimate strength of the material cannot be reasonably estimated, initial trials should be conducted using standard speeds until the ultimate strength of the material and the compliance of the system are known, and speed of testing can be adjusted. The suggested standard speed for cross head displacement is 6 mm/min [0.25 in./min].

11.5 *Test Environment*—If possible, test the specimen under the same fluid exposure level used for conditioning. However, cases such as elevated temperature testing of a moist specimen place unrealistic requirements on the capabilities of common testing machine environmental chambers. In such cases, the mechanical test environment may need to be modified, for example, by testing at elevated temperature with no fluid exposure control, but with a specified limit on time to failure from withdrawal from the conditioning chamber. Record any modifications to the test environment.

11.6 *Fixture Installation*—Arrange the loading fixture as shown in Fig. 1 as appropriate and place in the test machine.

11.7 *Specimen Insertion and Alignment*—Place the specimen into the test fixture. Align the fixture and specimen so that the longitudinal axis of the specimen is perpendicular (within 1°) to the longitudinal axes of the loading bars, and the bars are parallel (within 1°) to the plane of the specimen facings.

11.8 *Transducer Installation*—Attach the deflection transducer (LVDT) to the fixture and specimen, and connect to the recording instrumentation. Remove any remaining preload, zero the strain gages and balance the LVDT.

11.9 *Loading*—Apply a compressive force to the specimen at the specified rate while recording data. Load the specimen until failure or until a deflection equal to the specimen thickness is reached.

NOTE 7—Some core materials do not exhibit a well-defined fracture failure with sudden loss of load-carrying capacity, rather failures are characterized by a protracted yield of the core in shear, resulting in large core-shear deformation while continuing to carry load. Tests of such materials should be stopped within the limits of linear beam theory.

11.10 *Data Recording*—Record force versus crosshead displacement, and force versus LVDT deflection data continuously, or at frequent regular intervals (on the order of 2-3 recordings per second, with a target minimum of 100 recorded data points per test). If any initial failures are noted, record the force, displacement, and mode of damage at such points. Potential initial (non-catastrophic) failures that should be reported include: facesheet delamination, core-to-facesheet disbond, partial core fracture, and local core crushing. Record the mode, area and location of each initial failure. Use the failure identification codes shown in Table 1. Record the method used to determine the initial failure (visual, acoustic emission, etc.). Record the maximum force, the failure force, the head displacement and the LVDT deflection at, or as near as possible to, the moment of ultimate failure.

11.11 *Ultimate Failure Modes*—Record the mode, area and location of ultimate failure for each specimen. Use the failure identification codes shown in Table 1. Shear failures of the sandwich core or failures of the core-to-facing bond are the only acceptable failure modes. Failure of one or both of the facings preceding failure of the core or core-to-facing bond is not an acceptable failure mode.

12. Validation

12.1 Values for ultimate properties shall not be calculated for any specimen that breaks at some obvious flaw, unless such flaw constitutes a variable being studied. Retests shall be performed for any specimen on which values are not calculated.

12.2 A significant fraction of failures in a sample population occurring in one or both of the facings shall be cause to reexamine the loading and specimen geometry.

13. Calculation

13.1 *Force-Displacement Behavior*—Plot and examine the force-displacement data to determine if there is any significant compliance change (change in slope of the force-displacement curve, sometimes referred to as a transition region) prior to ultimate failure (significant is defined as a 10 % or more change in slope). An example of a transition region is shown in Test Method D 3410. Determine the slope of the force-displacement curve above and below the transition point using chord values over linear regions of the curve. Intersect the linear slopes to find the transition point. Report the force and displacement at such points along with the displacement values used to determine the chord slopes. Report the mode of any damage observed during the test prior to specimen failure.

13.2 *3-Point Mid-span Loading*:

13.2.1 *3-Point Mid-span Loading*—Calculate the core shear ultimate stress using Eq 4:

$$F_s^{ult} = \frac{P_{max}}{(d+c)b} \tag{4}$$

where:

F_s^{ult} = core shear ultimate strength, MPa [psi],
P_{max} = maximum force prior to failure, N [lb],
t = nominal facing thickness, mm [in.],
d = sandwich thickness, mm [in.],
c = core thickness, mm [in.] ($c = d - 2t$) see Fig. 2, and
b = sandwich width, mm [in.].

NOTE 8—Since it is generally not practical to accurately measure the facing thicknesses of co-cured sandwich panels, the calculations are based on nominal thicknesses specified by the test requestor.

NOTE 9—The first order approximation to the shear stress distribution through-the-thickness of a thin facesheet sandwich panel uses a linear distribution of shear stress in the facesheets starting at zero at the free surface and increasing to the core shear stress value at the facesheet-core interface. Therefore, the effective area of transverse shear stress is the core thickness + ½ of each facesheet thickness, which is equal to $c + t_1/2 + t_2/2 = (d + c)/2$.

13.2.2 *Core Shear Yield Stress*—For core materials that yield more than 2 % strain calculate the core shear yield stress using Eq 5:

$$F_s^{yield} = \frac{P_{yield}}{(d+c)b} \tag{5}$$

where:

F_s^{yield} = core shear ultimate strength, MPa [psi], and
P_{yield} = force at 2 % offset shear strain, N [lb].

13.2.3 *Facing Stress*—Calculate the facing stress using Eq 6:

$$\sigma = \frac{P_{max}S}{2t(d+c)b} \tag{6}$$

where:

σ = facing stress, MPa [psi],

TABLE 1 Sandwich Panel Three Part Failure Identification Codes

First Character		Second Character		Third Character	
Failure Type	Code	Failure Area	Code	Failure Location	Code
core Crushing	C	At load bar	A	Core	C
skin to core Delamination	D	Gage	G	core-facing bond	A
Facing failure	F	Multiple areas	M	Bottom facing	B
Multi-mode	M(xyz)	Outside gage	O	Top facing	T
transverse Shear	S	Various	V	both Facings	F
eXplosive	X	Unknown	U	Various	V
Other	O			Unknown	U

t = facing thickness, mm [in.], and
S = span length, mm [in.].

NOTE 10—The facing stress is calculated as a reference value at the maximum applied force. Since this test method is restricted to core or core-to-facing shear failures, the facing stress does not represent the facing ultimate strength. Use Test Method D 7249 to obtain the facing ultimate strength.

13.3 *4-Point (Quarter Point) Loading*:

13.3.1 *Core Shear Ultimate Stress*—Calculate the core shear ultimate stress using Eq 7:

$$F_s^{ult} = \frac{P_{max}}{(d + c)b} \tag{7}$$

13.3.2 *Core Shear Yield Stress*—For core materials that yield more than 2 % strain calculate the core shear yield stress using Eq 8:

$$F_s^{yield} = \frac{P_{yield}}{(d + c)b} \tag{8}$$

13.3.3 *Facing Bending Stress*—Calculate the facing bending stress using Eq 9:

$$\sigma = \frac{PS}{4t(d + c)b} \tag{9}$$

NOTE 11—The facing stress is calculated as a reference value at the maximum applied force. Since this test method is restricted to core or core-to-facing shear failures, the facing stress does not represent the facing ultimate strength. Use Test Method D 7249 to obtain the facing ultimate strength.

13.4 *4-Point (Third Point) Loading*:

13.4.1 *Core Shear Ultimate Stress*—Calculate the core shear ultimate stress using Eq 10:

$$F_s^{ult} = \frac{P_{max}}{(d + c)b} \tag{10}$$

13.4.2 *Core Shear Yield Stress*—For core materials that yield more than 2 % strain calculate the core shear yield stress using Eq 11:

$$F_s^{yield} = \frac{P_{yield}}{(d + c)b} \tag{11}$$

13.4.3 *Facing Bending Stress*—Calculate the facing bending stress using Eq 12:

$$\sigma = \frac{PS}{3t(d + c)b} \tag{12}$$

NOTE 12—The facing stress is calculated as a reference value at the maximum applied force. Since this test method is restricted to core or core-to-facing shear failures, the facing stress does not represent the facing ultimate strength. Use Test Method D 7249 to obtain the facing ultimate strength.

13.5 *Statistics*—For each series of tests calculate the average value, standard deviation, and coefficient of variation (in percent) for ultimate strength:

$$\bar{x} = \left(\sum_{i=1}^{n} X_i\right) / n \tag{13}$$

$$S_{n-1} = \sqrt{\left(\sum_{i=1}^{n} x_i^2 - n\bar{x}^2\right) / \left(n - 1\right)} \tag{14}$$

$$CV = 100 \times S_{n-1} / \bar{x} \tag{15}$$

where:
$\bar{x}$ = sample mean (average),
S_{n-1} = sample standard deviation,
CV = sample coefficient of variation, %,
n = number of tested specimens, and
x_1 = measured or derived property.

14. Report

14.1 Report the following information, or references pointing to other documentation containing this information, to the maximum extent applicable (reporting of items beyond the control of a given testing laboratory, such as might occur with material details or panel fabrication parameters, shall be the responsibility of the requestor):

NOTE 13—Guides E 1309 and E 1434 contain data reporting recommendations for composite materials and composite materials mechanical testing.

14.1.1 The revision level or date of issue of this test method.

14.1.2 The name(s) of the test operator(s).

14.1.3 Any variations to this test method, anomalies noticed during testing, or equipment problems occurring during testing.

14.1.4 Identification of all the materials constituent to the sandwich panel specimen tested (including facing, adhesive and core materials), including for each: material specification, material type, manufacturer's material designation, manufacturer's batch or lot number, source (if not from manufacturer), date of certification, and expiration of certification. Description of the core orientation.

14.1.5 Description of the fabrication steps used to prepare the sandwich panel including: fabrication start date, fabrication end date, process specification, and a description of the equipment used.

14.1.6 Method of preparing the test specimen, including specimen labeling scheme and method, specimen geometry, sampling method, and specimen cutting method.

14.1.7 Results of any nondestructive evaluation tests.

14.1.8 Calibration dates and methods for all measurements and test equipment.

14.1.9 Details of loading platens and apparatus, including loading configuration, loading and support span dimensions, loading bar details and material(s) used.

14.1.10 Type of test machine, alignment results, and data acquisition sampling rate and equipment type.

14.1.11 Type, range and sensitivity of LVDT, or any other instruments used to measure loading platen deflection.

14.1.12 Measured lengths, widths and thicknesses for each specimen.

14.1.13 Weight of specimen, if requested.

14.1.14 Conditioning parameters and results.

14.1.15 Relative humidity and temperature of the testing laboratory.

14.1.16 Environment of the test machine environmental chamber (if used) and soak time at environment.

14.1.17 Number of specimens tested.

14.1.18 Speed of testing.

14.1.19 Facing thicknesses used in the calculations.

14.1.20 Individual ultimate shear strengths and average value, standard deviation, and coefficient of variation (in percent) for the population.

14.1.21 Individual facing stresses at maximum applied force and average value, standard deviation, and coefficient of variation (in percent) for the population.

14.1.22 Force versus crosshead displacement data for each specimen.

14.1.23 Force versus LVDT deflection data for each specimen.

14.1.24 Failure mode and location of failure.

15. Precision and Bias

15.1 *Precision*—The data required for the development of a precision statement is not available for this test method.

15.2 *Bias*—Bias cannot be determined for this method as no acceptable reference standards exist.

16. Keywords

16.1 bending stress; core modulus; core stress; facing stress; sandwich construction; sandwich deflection; shear stress